Summary of Plays

The United States Geological Survey identifies several petroleum plays in the San Juan Basin Province and classifies them as Conventional or Unconventional. The discussions that follow are limited to those with direct significance for future petroleum development in the Southern Ute Indian Reservation.

Play Types

Conventional Plays- Discrete Deposits, usually bounded by a downdip water contact, from which oil, gas or NGL can be extracted using traditional development practices, including production at the surface from a well as a consequence of natural pressure within the subsurface reservoir, artificial lifting of oil from the reservoir to the surface where applicable, and the maintenance of reservoir pressure by means of water or gas injection

Unconventional Plays- A broad class of hydrocarbon deposits of a type (such as gas in "tight" sandstones, gas shales, and coal-bed gas) that historically has not been produced using traditional development practices. Such accumulations include most continuous-type deposits.

Reservation: Southern Ute
Geologic Province: Paradox & San Juan Basin
Province Area: Paradox Basin (33,000 sq. miles) San Juan Basin (22,000 sq. miles)
Reservation Area: 553,008 acres

Total Production

Oil: San Juan Basin Cumulative Totals >240,000,000 BO
Gas: >18,000,000,000 CFG
NGL: Included
(figures from NMOGA, 1997 & FCGS, 1983)

Undiscovered resources and numbers of fields are for Province-wide plays. No attempt has been made to estimate number of undiscovered fields within the Southern Ute Indian Reservation.

Play Type	USGS Designation	Description of Play	Oil or Gas	Known Accumulations	Undiscovered Resource (MMBOE) Field Size (> 1 MMBOE) median, mean	Play Probability (chance of success)	Drilling depths (feet)	
1 Porous Carbonate Buildup Play	2102,2201	Mounds of algal limestone in the Paradox Formation of the Hermosa group.	Both	Gas (448,740 MMCFG) Oil (521,090 MBO)	Gas (10 BCFG, 131 BCFG) Oil (4 MMBO, 6.3 MMBO)	1.0	Gas (4000, 6000, 14000) Oil (2500, 6000, 14000)	
2 Entrada Play	2204	Associated with relict dune deposits on top of the Jurassic Entrada Sandstone.	Oil	Oil (4,360 MBO)	Oil (2 MMBO, 1.8 MMBO)	1.0	Oil (3000, 6000, 9000)	
3 Basin Margin Dakota Oil Play	2206	Mostly upper marine part of the Dakota sandstone.	Both	Gas (62,100 MMCFG) Oil (22,589 MBO)	Gas (10 BCFG, 12.1 BCFG) Oil (2 MMB0, 2.8 MMBO)	1.0	Gas (1000, 2000, 2000) Oil (600, 2000, 5000)	
4 Tocito-Gallup Sandstone Oil Play	2207	Lenticular sandstone bodies of Upper Cretaceous Tocito and Gallup Sandstones.	Both	Gas (199,800 MMCFG) Oil (174,135 MBO)	Gas (30 BCFG, 38.0 BCFG) Oil (4 MMBO, 6.3 MMBO)	1.0	Gas (4000, 6000, 8000) Oil (1000, 5000, 8000)	
5 Basin Margin Mesa Verde Oil Play	2210	Intertonguing of porous marine sandstone at base of the Upper Cretaceous Point Lookout Sandstone with the organic rich upper Mancos Shale.	Oil	Gas (7.8 BCFG, estimated mean) Oil (7.8 MMBO, estimated mean)	Oil (2 MMBO, 1.9 MMCO)	0.8	Oil (300, 2000, 4000)	
6 Fruitland-Kirtland Fluvial Sandstone Gas Play	2212	Lenticular fluvial sandstone bodies enclosed in shale source rocks and (or) coal.	Gas	Gas (1,505,520 MMCFG)	Gas (18 BCFG, 23.2 BCFG)	1.0	Gas (1000, 2000, 4000)	

Table 1. Play summary chart.

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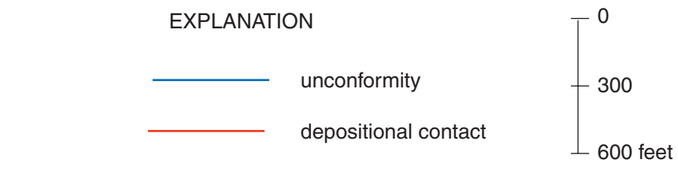
Play Type	USGS Designation	Description of Play	Oil or Gas	Known Accumulations	Undiscovered Resource (MMBOE) Field Size (> 1 MMBOE) median, mean	Play Probability (chance of success)	Drilling depths (feet)		
7 Dakota Central Basin Gas Play	2205	Coastal marine barrier-bar sandstone and continental fluvial sandstone units, primarily within the transgressive Dakota Sandstone.	Gas	Gas (8211.28 BCFG) (estimated mean)	N / A	1.0	Gas (5000, 6900, 8000)		
8 Mancos Fractured Shale Play	2208	Fractured organic rich marine Mancos Shale.	Oil	Gas (94.42 BCFG) (estimated mean) Oil (188.85 MMBO) (estimated mean)	N / A	1.0	Oil (1000, 3000, 7000)		
9 Central Basin Mesaverde Gas Play	2209	Sandstone buildups associated with stratigraphic rises in the Upper Cretaeous Point Lookout and Cliff House Sandstones.	Gas	Gas (7,000 BCFG)	N / A	1.0	Gas (1000, 2600, 5000)		
10 Pictured Cliffs Gas Play	2211	Sandstone reservoirs enclosed in shale or coal at the top of the Pictured Cliffs Sandstone.	Gas	Gas (3264.04 BCFG) (estimated mean)	N / A	1.0	Gas (1000, 2100, 3600)		
11 Coal Bed Gas Play: Overpressured Play	2250	North-Central part of the basin and north of the structural hingeline where recharge of fresh water takes place.	Gas	Gas (4165.41 BCFG) (estimated mean)	N / A	1.0	Gas (500, 2809, 4200)		
12 Coal Bed Gas Play: Underpressured Discharge Play	2252	South of the structural hingeline of the basin where coal beds are underpressured.	Gas	Gas (2143.84 BCFG) (estimated mean)	N / A	1.0	Gas (500, 1402, 4000)		
13 Coal Bed Gas Play: Underpressured Play	2253	Eastern part of the basin where ground water flow is sluggish.	Gas	Gas (1223.78 BCFG) (estimated mean)	N / A	1.0	Gas (500, 2446, 4000)		

Table 2. Play summary chart - *continued*

Two logs were chosen to represent the stratigraphy of the Southern Ute Indian Reservation. Their locations are marked on the figure below. Together they represent the stratigraphy from Devonian - Tertiary. The logs show the SP/Gamma and Resistivity profile of their respective rock units.

Well #1 **ARCO S. Ute 33-11 No. 10-1**
Sec 10, T33N, R11W
(Molenaar, C.M., and Baird, J.K., 1989)

Well #2 **GENERAL PETROLEUM CORP. No. 55-17 Kikel**
Sec 17, T34N, R11W,
(Condon, S.M., and Huffman, A.C., 1994)



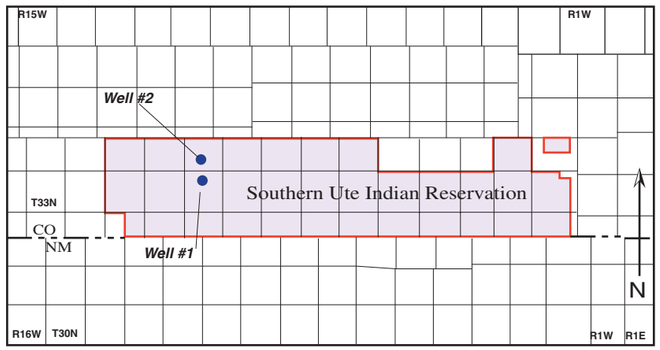
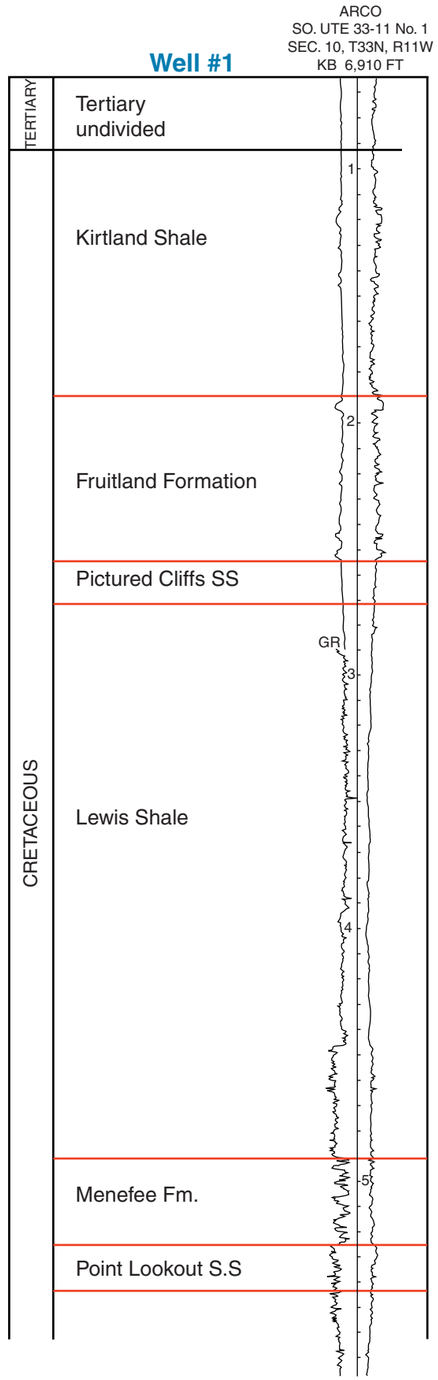
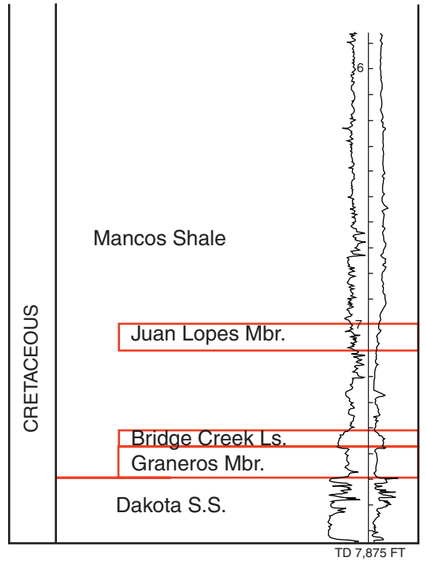
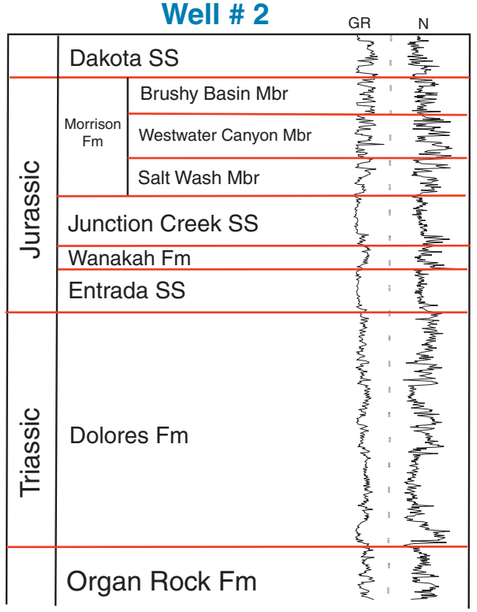
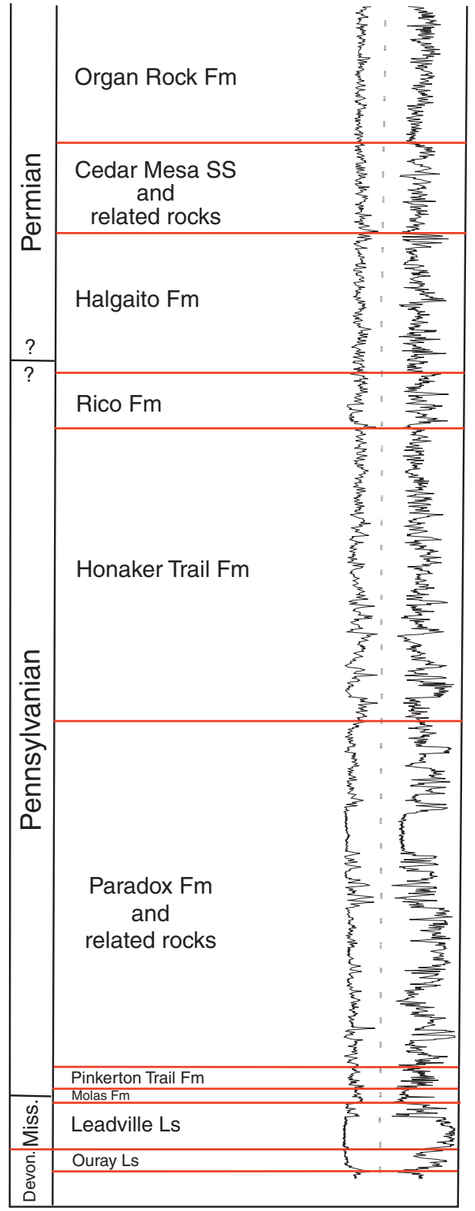


Fig. SU-10 Location of Type Logs in Southern Ute Indian Reservation.









Porous Carbonate Buildup Play

(USGS 2201)

General Characteristics

The Porous Carbonate Buildup Play in this province is primarily a gas play and is characterized by oil and gas accumulations in mounds of algal (Ivanovia) limestone associated with organic-rich black shale rimming the evaporite sequences of the Paradox Formation of the Hermosa Group. Most developed fields within the play produce from combination traps on the Four Corners platform or in the Paradox Basin province, but for this analysis, the play was extended southeast to the limit of the black shale facies, roughly corresponding to the limit of the central San Juan Basin.

Reservoirs: Almost all hydrocarbon production has been from vuggy limestone and dolomite reservoirs in five zones of the Hermosa Group: (in ascending order) the Alkali Gulch, Barker Creek, Akah, Desert Creek, and Ismay. The zones gradually become less distinct toward the central part of the San Juan Basin. Net pay thicknesses generally vary from 10 to 50 ft and have porosities of 5-20 percent.

Source rocks: Source beds for Pennsylvanian oil and gas are believed to be organic-rich shale and laterally equivalent carbonate rocks within the Paradox Formation. The presence of hydrogen sulfide (H_2S) and appreciable amounts of CO_2 at the Barker Creek and Ute Dome fields probably indicates high-temperature decomposition of carbonates. Correlation of black dolomitic shale and mudstone units of the Paradox Formation with prodelta facies in clastic cycles present in a proposed fan delta complex on the northeastern edge of the Paradox evaporite basin helps to account for the high percentage of kerogen from terrestrial plant material in black shale source rocks.

Timing and migration: In the central part of the San Juan Basin, Pennsylvanian sediments entered the thermal zone of oil generation during the Late Cretaceous to Paleocene and the dry gas zone during the Eocene to Oligocene. It also is probable that Pennsylvanian source rocks entered the zone of oil generation during the Oligocene throughout most of the Four Corners Platform. Updip migration and local migration from laterally equivalent carbonates and shale beds in areas of favorable reservoir beds predominate, and remigration may have occurred in areas of faulting and fracturing.

Traps: Combination stratigraphic and structural trapping mechanisms are dominant among Pennsylvanian fields of the San Juan Basin and Four Corners Platform. Most fields are located on structures, although not all of these structures demonstrate closure. The structures themselves may have been a critical factor in the deposition of bioclastic limestone reservoir rocks. Seals are provided by a variety of mechanisms including porosity differences in the reservoir rock, overlying evaporites, and interbedded shale. Most production on the Four Corners Platform is from depths of 5,100 to 8,500 ft, but minor production and shows in the central part of the San Juan Basin are from as deep as 11,000 ft.

Exploration status and resource potential: Field sizes in the play vary considerably. Most oil discoveries are in the 1–100 MMBO size range and include associated gas production. The largest fields, Tocito Dome and Tocito Dome North, have produced a total of about 13 MMBO and 26 BCFG. Eight significant nonassociated and associated gas fields have been developed in the play, the largest of which, Barker Creek, has produced 205 BCFG. The Pennsylvanian is basically a gas play and has a moderate future potential for medium-size fields.

Characteristics of the Porous Carbonate Buildup Play

In the Southern Ute Indian Reservation, the Paradox Formation is conformably bounded by the Pinkerton Trail Formation at its base and the Honaker Trail Formation at its top (Fig. SU-3). It ranges from 800 feet thick in the south to 1700 feet thick in the north. The Paradox Formation was deposited during Desmoinesian age of the Pennsylvanian Period under strong cyclic conditions involving transgressive and regressive movements of the Pennsylvanian sea. The transgressive phase is represented by black organic rich dolomitic muds while the regressive phase is represented by carbonate mounds. Reservoirs within the reservation are biogenic/bioclastic carbonate mounds deposited in shoaling areas of an evaporite basin. The four main cycles of Desmoinesian deposition are the Barker Creek, Akah, Desert Creek, and Ismay Stages (Fig. SU-10).

Barker Creek Stage strata have a gross thickness of 500 feet. It is a fossiliferous, algal, dolomitic limestone with vuggy, secondary dolomite. Most reservoir rock is algal, dolomitic limestone with enhanced porosity and permeability due to dolomitization and weathering. The Barker Creek was deposited on paleostructural features related to the Hogback lineament.

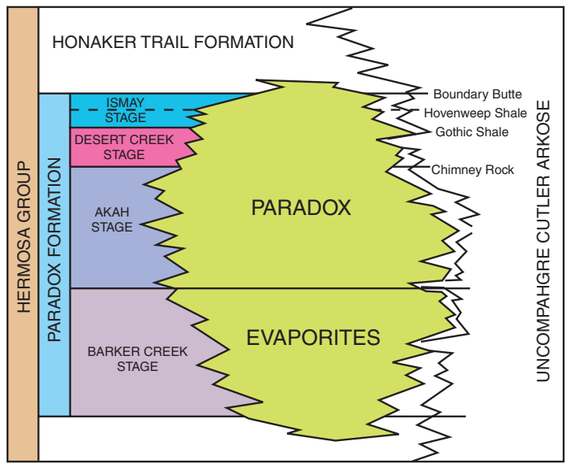


Figure SU-10. Stratigraphic chart of the Pennsylvanian Hermosa Group illustrating the Paradox Formation facies changes across the basin. Each stage is bounded by a time stratigraphic marker bed of sapropelic, dolomitic mudstone. These markers are continuous and mappable throughout the basin (modified after Harr, 1996).

Akah Stage rocks are not considered to be an exploration objective within the reservation because salt and anhydrite deposition was dominate at this time. The Akah Stage represents the maximum extent of evaporite limits (Fig. SU-10).

Desert Creek Stage carbonates were deposited in a definable arcuate trend around the southeast terminus of the basin. The Desert Creek is bounded by the Chimney Rock and Gothic Shales which represent transgressions. Growth of the Desert Creek carbonate bank occurred during slow subsidence of the Paradox Basin. Source rocks for hydrocarbons are the Chimney Rock and Gothic Shales (Fig. SU-10).

The Ismay Stage is divided into lower and upper units. The lower unit is bounded by the Gothic and Hovenweep Shales (Fig. SU-10). During the Ismay Stage the southern part of the basin was slowly subsiding. Oil is produced from algal carbonate buildups. The upper unit is bounded by the Hovenweep and Boundary Butte Shales (Fig. SU-10). Production is from algal or bioclastic/biogenic reservoirs. The source rocks for Ismay rocks are the Gothic, Hovenweep, and Boundary Butte Shales.

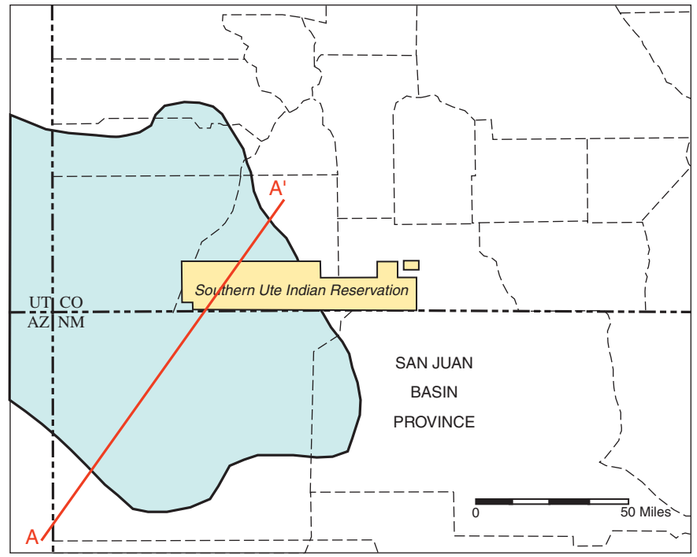


Figure SU-11. Location of the Porous Carbonate Buildup Play (modified after Gautier et al., 1996).

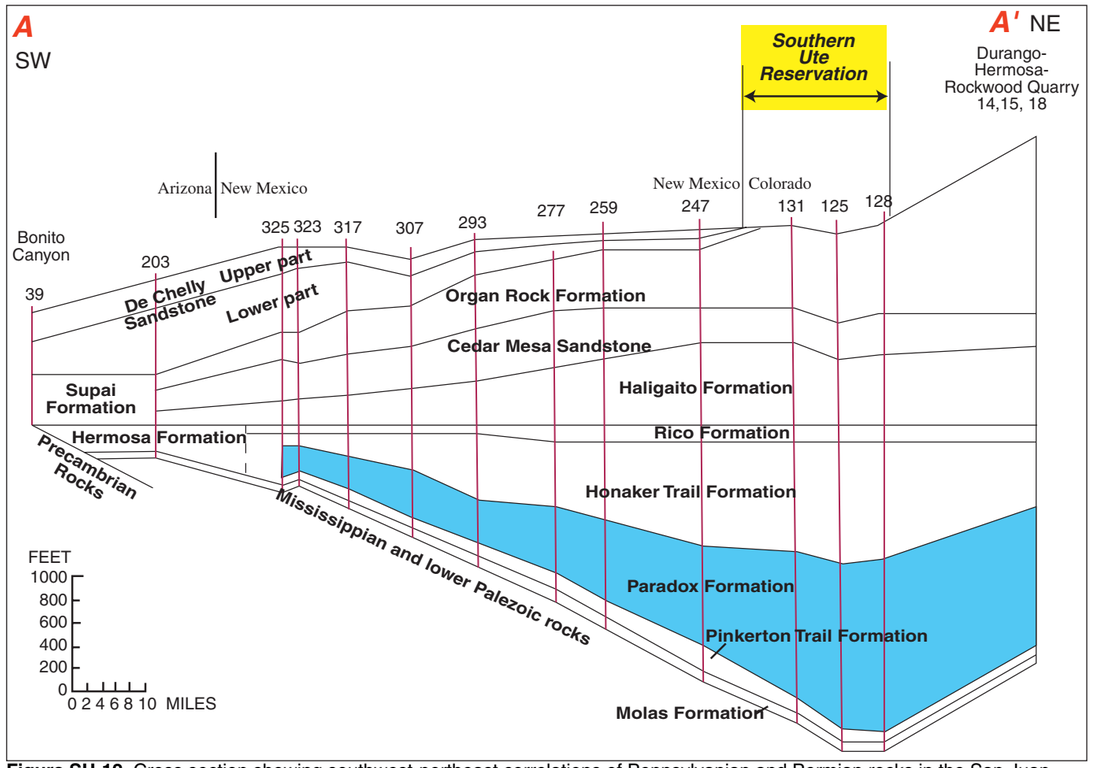


Figure SU-12. Cross section showing southwest-northeast correlations of Pennsylvanian and Permian rocks in the San Juan Basin and adjacent areas. Line of section is shown in Figure SU-11 (modified after Condon, 1992).

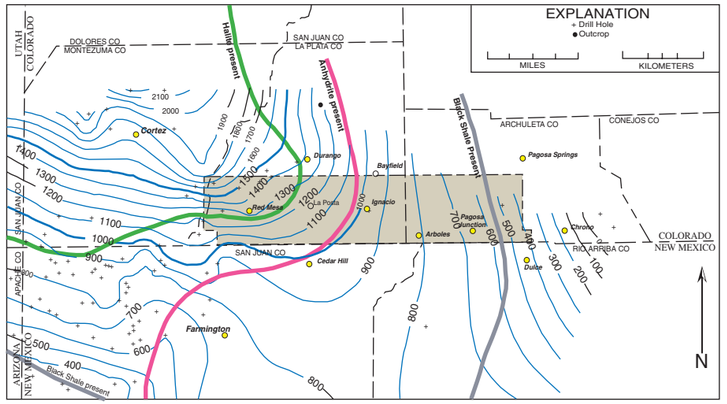


Figure SU-13. Isopach map of the Paradox Formation and equivalent rocks of the Hermosa Group. Contour interval is 100 feet (modified after Condon, 1992).

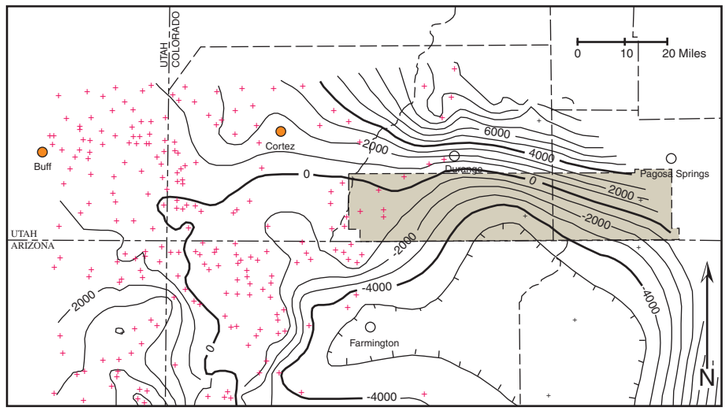


Figure SU-14. Structure contour map of the top of the Rico Formation. Contour interval is 1000 feet (modified after Huffman and Condon, 1993).

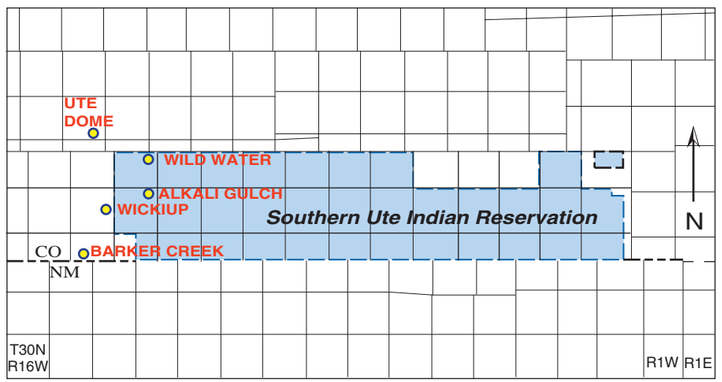


Figure SU-15. Location of oil and gas field discovery wells for fields producing from the Porous Carbonate Buildup Play.

Analog Fields In and Near Reservation

(*) denotes field lies within the reservation boundaries

* Wildwater

(see Figure SU-16)

Location of discovery well:	ne, sw, sec 2, T34N, R13W (1974)
Producing formation:	Paradox Formation
Type of trap:	Structure-Stratigraphic
Number of producing wells:	1 (1977)
Initial production:	1040 MCFGD
Cumulative Production:	N/A
Gas characteristics:	BTU 1,165
Oil characteristics:	63˚ API gravity, light, yellowish green
Type of drive:	Gas expansion
Average net pay:	13 feet
Porosity:	6.6 %
Permeability:	N/A

* Alkali Gulch West

Location of discovery well:	c, new,sw, sec 2, T33N, R13W (1981)
Producing formation:	Ismay Zone of the Paradox Formation
Type of trap:	Stratigraphic
Number of producing wells:	1 (1992)
Initial production:	1.152 MCFGD, 6BWD
Cumulative Production:	369,633 MCFG, 423 B condensate (1992)
Gas characteristics:	97.75% methane, 1.23 % ethane, 0.32 % propane
Type of drive:	Gas expansion
Average net pay:	66 feet
Porosity:	8%
Permeability:	N/A

Wickiup

Location of discovery well:	sw se sec 24, T33N, R14W (1972)
Producing formation:	Barker Creek Zone of the Paradox Formation
Type of trap:	Stratigraphic
Number of producing wells:	1 (1977)
Initial production:	1,970 MCFGD, 842 BWD
Cumulative Production:	20,603 MCFG (1982)
Gas characteristics:	BTU 914
Type of drive:	Gas expansion
Average net pay:	10 feet
Porosity:	8%
Permeability:	N/A

Barker Creek

Location of discovery well:	se, se, nw, sec 21, T32N, R14W (1945)
Producing formation:	Paradox Formation
Type of trap:	Structural
Number of producing wells:	5 (1977)
Initial production:	42,000 MCFGD
Cumulative Production:	115,237,890 MCFG, 109,462, B condensate (1994)
Gas characteristics:	BTU 1,026 sweet gas, BTU 875 sour gas
Type of drive:	Solution gas, fluid expansion
Average net pay:	± 100 feet (individual pay zones range 10-80 ft)
Porosity:	2-10 % (vugs and fractures)
Permeability:	extremely variable due to vugs and fractures)

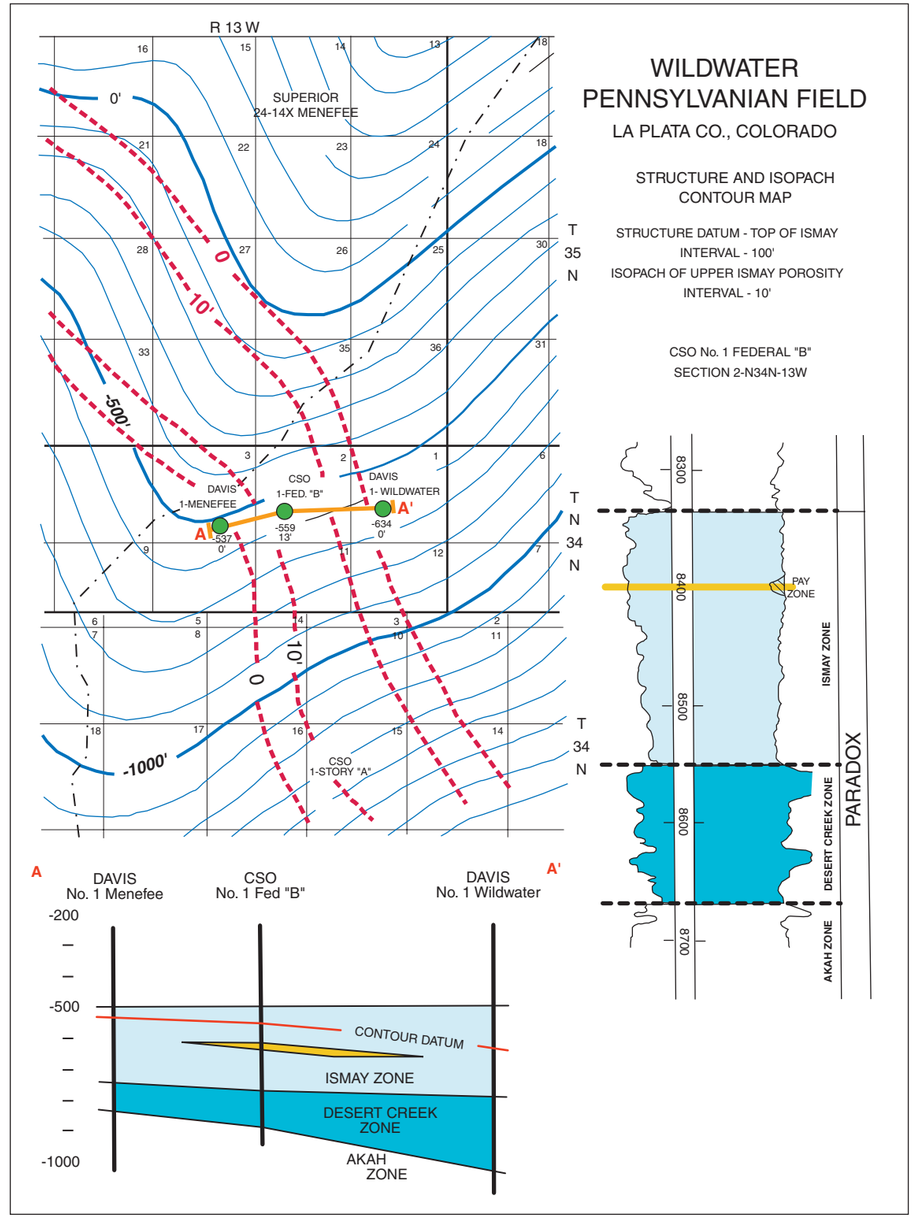


Figure SU-16. Structure contour map, structural cross section, and type log from the Wildwater Pennsylvanian field (modified after Bevacqua, 1983).